AN ANALYSIS OF THE EFFECTS OF MODELING BRIGADE TEMPLATES IN CAMEX

THESIS

Douglas A. Hersh, Captain, USA

AFIT/GOR/ENS/94M-06

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT/GOR/ENS/94M-06

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THESIS

Presented to the Faculty of the Graduate School of Engineering

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Douglas A. Hersh, B.S.

Captain, USA

March 1994

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Douglas A. Hersh

Thesis Approval

STUDENT: Captain Douglas A. Hersh CLASS: GOR-94M

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Advisor	Dr. Joseph P. Cain/ENS	
Reader	MAJ Edward P. Negrelli/ENS	

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Abstract

This thesis effort modeled brigade-sized templates within the CAMEX model, and determined the effects of those templates on the direct fire attrition methodology. The model simulated combat between a U.S. brigade from a mechanized or armored division and a Soviet-style motorized rifle regiment. Three different scenarios were used to simulate combat between the forces. The scenarios included a movement to contact, an attack, and a deliberate defense. Each scenario was run using the battalion-sized templates and again with the brigade-sized templates. The results revealed that use of the model with brigade-sized templates will demonstrate similar results to those obtained using battalion-sized templates. The simulations also demonstrated a possible flaw in the representation of certain weapons systems such as the Bradley Fighting Vehicle. The use of brigade-sized templates shows promise as a way to decrease data entry requirements and speed scenario development. However, the gains are not without costs in terms of lost ability to replicate tactics at the battalion level.

AN ANALYSIS OF THE EFFECTS OF MODELING BRIGADE TEMPLATES IN CAMEX

I. Introduction

General

The purpose of this thesis is to examine the direct fire attrition methodology used by VIC (Vector In Commander) and CAMEX (Computer Assisted Map EXercise), two of the Army's land combat models, and to develop and test unit templates which will allow the use of higher echelon entities in the models. This chapter provides background information concerning my efforts to increase the efficiency of scenario development for VIC and CAMEX. The first portion of the chapter describes the Army's reliance on models and simulations. The second part provides a brief overview of VIC and CAMEX. The third part identifies the problem with the existing models and the objective of the model improvement. This section is followed by an outline of development and testing of the unit templates. The final portion outlines the organization of my thesis.

Background

Modeling and simulation are considered two of our nation's critical defense technologies. A military model is an abstraction of reality, the elements of which are chosen for (a) an investigative purpose or (b) a resource management (11:3). Models produce quantitative measurements of the effectiveness of weapons, forces, and policies, and, as such, provide the decisionmaker with analyses that influence decisions (9:20). The defense community uses models for two primary purposes--analysis and training. Typical analytical uses include (8:194):

1) Weapons System Analysis
2) Development of Tactics
3) Force Structure Problems
4) Studies of Force Deployment and Employment
5) Determination of Force Levels

Training applications include skill development and exercise drivers (2:4). The Army uses models and simulations at all echelons.

The Army has developed a system of exercises known as the Louisiana Maneuvers, named after the 1940 exercise that was used to prepare the Army prior to World War II, to prepare for the challenges of the twenty-first Century. The

Army will harness the power of the microprocessor to overcome high costs and land use constraints by using computer-supported simulations to replicate roles and missions, ranging from a full-scale theater operation to a sophisticated counter-drug campaign, a small-scale strike operation, or a mobilization exercise (6:59). The development of the Louisiana Maneuvers along with the creation of "battle labs" virtually ensures the Army's continued reliance on models and simulations.

Models

The Army's Model Improvement Program has designated Vector-in-Commander (VIC) to be the deterministic Corps level model in the Army's family of simulations (FAMSIM). VIC was designed to model AirLand Battle doctrine at the Corps-Division level. VIC is a two-sided deterministic simulation of combat at the division-corps level. VIC primarily models ground combat, but can replicate air combat in the form of tactical air missions and helicopter operations. The standard unit size of the entities used to portray ground combat are the Blue battalion and the Red battalion. VIC is routinely used by the Operations Analysis

Center of the TRADOC Analysis Center at Fort Leavenworth to provide insights into force development issues.

CAMEX is a comprehensive, computer-assisted map exercise developed to simulate the significant aspects of Army doctrine in a Corps-level scenario (16:1). CAMEX is an interactive model based on VIC's methodology. CAMEX gained some notoriety when it was used as the exercise driver for the 1993 Louisiana Maneuvers. This exercise tested the operational concept of the Mobile Strike Force (MSF) using representatives from the Army's "battle labs" as the MSF staff.

Problem Statement

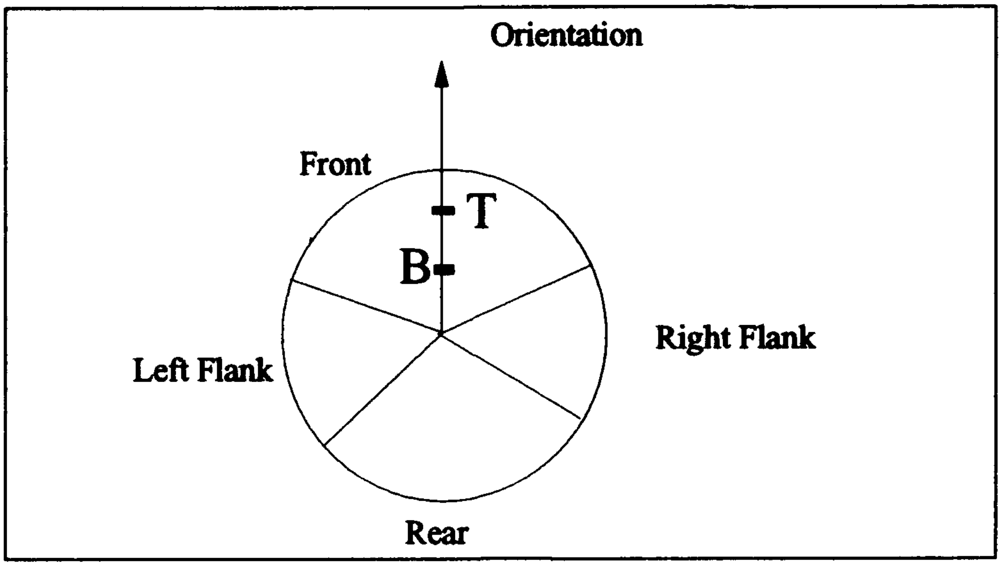
In the current environment, analysts are being asked to provide more rapid responses to a variety of questions than ever before. In the recent Gulf War, most of the battle plans were run through detailed simulations prior to their execution. These simulations greatly assisted the planners by providing insights which in many cases caused changes in the battle plans. The need for rapid responses by analysts was espoused by the Director of the TRADOC Analysis Center, Michael F. Bauman at the 61st Military Operations Research Society Symposium, when he stated that analysts must be able

to answer the quick "what ifs?" in order to increase their utility.

Like many other higher-level combat models, VIC and CAMEX are dependent upon huge databases which store attributes such as movement rates, rates of fire, ranges of sensors and weapons, and weapons effects, for the various model entities. In order to perform useful analysis, considerable time is invested in the preparation of the order of battle for each simulated scenario. For corps-level scenarios, data entry can take weeks. In both VIC and CAMEX, the normal unit modeled is the Blue battalion. By increasing the size of the standard unit to brigade, the data entry requirements can be greatly streamlined. For instance, a U.S. mechanized infantry division has five mechanized infantry battalions, five armor battalions that must be represented using battalion-sized entities, and three brigade headquarters that are represented by company-sized entities. By modeling brigade entities, only three are required. Representation of an armored division allows a similar decrease in data entry. Using brigade-size entities, the requirements for data entry are one fourth of amount of data required to portray battalion-size entities.

Unit Representation

A unit in VIC can be a division, a brigade, a battalion or a company, or any other echelon of a military organization. Each unit in VIC is represented by a circular template. Each template is divided into four parts -- Front, Right Flank, Left Flank, and Rear. To represent the physical deployment of the unit on the ground, each of the four pie shapes is assigned a portion of the unit's assets such as weapons systems, vehicles, and personnel. This apportionment is done for each system represented within the unit. The system is placed in the pie shape by using the system's average distance from the center of the unit. This distance is important because it is used by the model to determine ranges between target-firer pairs. Each system placed in a pie shape represents an aggregate of that weapons system. For instance, a unit with forty percent of its 58 tanks in the front pie shape would have an aggregate that represented 23.2 tanks. This method of apportionment is used to implicitly represent the subunits of the unit.



"T" REPRESENTS THE DISTANCE FROM THE CENTER OF THE AGGREGATE OF TANKS THAT WERE PLACED IN THE FRONT SUBUNIT
"B" REPRESENTS THE DISTANCE FROM THE CENTER OF THE TEMPLATE OF THE AGGREGATE OF THE BRADLEY FIGHTING VEHICLES THAT WERE PLACED IN THE FRONT SUBUNIT

Fig. 1. A Unit Template

Purpose

The purpose of this thesis is to develop and test unit templates which will allow the use of brigades as the standard unit rather than battalions. As a rule, each brigade can control two to five battalions and supporting combat support (CS) and combat service support (CSS) elements (4:1-5). Standard brigade organization from

divisional tables of organization and equipment is three or four battalions per brigade.

Methodology

Each unit in VIC is represented by a circular template. The templates provide the location of the personnel, vehicles, and weapons systems within each unit. I will develop a template to represent a U.S. divisional brigade which contains two mechanized infantry battalions and two armor battalions. This template will be tested against an identically organized brigade represented by five templates: four battalion templates and a brigade headquarters template. The two aggregation levels will be compared using CAMEX with the unclassified database. The attrition methodology used in CAMEX is a based the methodology used in VIC, the parent model of CAMEX. The comparisons will use three scenarios -- movement to contact, hasty attack, and defense. Each blue force will face a Soviet-style motorized rifle regiment as an adversary. The red forces will be represented in a similar manner. The base line will use existing templates (battalion-level). The motorized rifle regiment will be represented by an aggregated regimental template when fighting the aggregated brigade template.

The results will be compared within each scenario on a first order basis to determine which side won each run. I will use several measures of effectiveness in the comparison of the two methods. The first measure of effectiveness will be the percentage of the blue force remaining at the end of the simulation run in terms of combat power. The second measure of effectiveness will be the percentage of the red force remaining at the end of the simulation run in terms of combat power. Combat power is measured from the start using a value based on T-62 equivalents. I will also examine the cumulative killer-victim data of each engagement. I will focus on the destruction of the primary weapons systems of the two forces--the tank and the infantry fighting vehicle.

Thesis Organization

Chapter II reviews of the subject models, VIC and CAMEX, and the direct fire attrition methodology employed in both models. Chapter III covers the formulation, coding, and testing of the unit templates used to represent a divisional brigade. Chapter IV discusses the results of testing the two levels of aggregation. Chapter V provides a synopsis of my efforts and results, and offers recommendations for future research.

II. Model and Direct Fire Attrition Methodology Review

Introduction

The purpose of this chapter is to review the methodology used by VIC and CAMEX. The first section reviews the development of Lanchester models. The next section reviews the types of large scale (Corps/Theater) combat models. The following section reviews the development and methodology of VIC and CAMEX. The final section provides a detailed review of the direct fire attrition methodology used by VIC and CAMEX.

Early Development

Modern deterministic models of combat got their start in 1914 when F.W. Lanchester published a series of articles in the British journal, Engineering. These articles were later reprinted in his book, Aircraft in Warfare: The Dawn of the Fourth Arm. Lanchester developed two primary laws -- the square law and the linear law. These laws form the basis for many modern combat models.

The square law was an attempt to model modern battle by explaining the effects of concentrated fire. Lanchester

hypothesized that "the number of men knocked out per unit of time will be directly proportional to the numerical strength of the opposing force." (12:42) This can be expressed mathematically by:

$$\frac{dx}{dt} = -ay \quad \text{with} \quad x(0) = x_0$$

$$\frac{dy}{dt} = -bx \quad \text{with} \quad y(0) = y_0$$

where t denotes the battle time, the battle begins at t = 0, and a and b are constants called Lanchester attrition-rate coefficients. These attrition-rate coefficients represent the effectiveness of each side's firepower. (16:57). The above equations yield the instantaneous casualty exchange ratio:

$$\frac{dx}{dy} = \frac{ay}{bx}$$

This can be integrated to yield the "square law":

$$b(x_0^2 - x^2) = a(y_0^2 - y^2) \quad \text{or}$$

$$bx^2 = ay^2 \quad \text{(Lanchester's original square law)}$$

In other words, the fighting strengths of the two forces are equal when the square of the numerical strength multiplied by the fighting value of the individual units are equal (12:48).

Approaches to Theater Level Models

Extensive research in the field of combat modeling has occurred since the development of Lanchester equations. There are three main approaches used for assessing outcomes (in particular, casualties) of simulated tactical engagements:

1) firepower-score approach
2) Monte Carlo simulation approach
3) Lanchester-type model approach (18:446).

Of these, the use of Monte Carlo simulations has been confined to the lower level analysis such as battalion and below. Because of our focus on large unit engagements, discussion will be limited to the firepower-score approach and hybrid analytical simulation models which use deterministic differential (Lanchester) equations.

Firepower Score Models

The firepower score approach is basically a technique for aggregating heterogeneous forces (i.e. tanks, artillery, infantry, etc.) into a single homogeneous force on each side (18:21). The firepower score approach measures the combat power of a unit by summing the combat power values for each weapon system in the unit (10:40). The resulting value of the summation is known as a firepower index. The firepower indices of opposing sides are then in general used to :

1) determine engagement outcomes
2) assess casualties
3) determine FEBA movement (18:23).

The ratio of the firepower index of the attacker to the firepower index of the defender is known as the force ratio. The concept of firepower indices as they relate to attrition is rather straightforward and logical. In practice, however, the methodology is, for numerous reasons, contrived, and found wanting for use beyond that of a static indicator in effecting crude force comparisons (13:19). One of the biggest problems is how to determine the firepower scores. Methods include:

1) Measures of Perceived Combat Value - scores derived from military experience and judgment.

2) Measures of Historical Combat Performance - scores derived from war data from conflicts such as WW2 and Korea.

3) Measures of Weapon Firepower - scores derived from daily ammunition expenditure multiplied by lethal area per round (for artillery and other area weapons) or by probability of kill (for tanks and other point fire weapons).

4) Measures of Mission Dependent Firepower - sets of scores were developed for both attack and defend missions.

5) Measures of Multiple Characteristics of the Weapons System - scores which combined factors such as firepower, mobility, vulnerability, and reliability using Delphi methodology; commonly known as WEI/WUV (Weapons Effectiveness Index/Weighted Unit Value)

6) Measures of What a Weapon Can Kill - scores that are proportional to the total of the scores for all the enemy weapons systems it can kill; derived using a system of circular eigenvalue equations known as the Potential-Anti-Potential Method. (10:40-41)

Other problems stem from the nature of the aggregation. Because the firepower index is additive in nature, the index cannot represent interactions between weapons systems such as a laser designator mounted on a scout helicopter and precision guided rounds from an artillery cannon. Since the firepower index is linear in nature, it can not show diminishing marginal returns as the number of any weapons system becomes too large, nor can it show a minimum unit size. Another problem is that the method loses track of the individual weapons systems represented in the index because of the aggregation. Losses of individual weapon system

types are determined by some means of disaggregation. Such aggregated loss-rate relations are apparently largely judgmentally determined (although having some alleged basis in empirical combat data) (18:450). Despite the inherent problems in the firepower score approach, combat simulations which use this form of attrition modeling are still used for analysis of theater level problems.

Hybrid Analytical Simulation Models

Research by Bonder and Farrell led to the development of hybrid analytical simulation models. A hybrid analytical simulation model combines a detailed combat process simulation with analytical techniques. Vector Research developed the first of these models. These researchers hypothesized that there exists a functional relation between the results of battle and the initial numbers of forces, types and capabilities of their weapon systems, their doctrine of employment, and the environment (18:503). They model combat using classes of engagements on each side (i.e. infantry vs infantry, infantry vs. tanks, tanks vs. tanks, etc.), in which fractional allocations are made of the weaponry within a type of unit on one side against some or all types of units on the other side (13:42). Attrition is

determined by generalized differential equations that are extensions of Lanchester equations. Measurable weapons systems parameters, rather than historical data, are used in computing the attrition coefficients for the modified Lanchester equations (13:34). Early examples of these models were Bonder/IUA, DIVOPS, VECTOR-1, and VECTOR-2.

Development of VIC

Development of VIC started in 1982 at the TRADOC Analysis Center at White Sands Missile Range (then TRASANA) in response to a requirement for a corps level simulation that could replicate combat in an AirLand Battle environment. The developers used two existing models to create VIC. The models were the VECTOR-2 and the COMMANDER. VECTOR-2, a product of Vector Research, represents deterministic ground and air theater combat among several kinds of units (10:6). VECTOR-2 was a hybrid analytical simulation model which used firer-target pairs by class of weapons system to determine attrition. COMMANDER , an Air Force model, was a theater air and ground combat model. Its chief virtues were its modular structure, a detailed air model, and use of Simscript II.5 as a programming language. The ground force part of the model uses a homogeneous

aggregation scheme [Firepower Score Approach], measuring combat power of a ground unit in "T62 tank equivalents" (10:7). The developers took the modular structure and programming language from COMMANDER to provide the basis for the model. VECTOR-2 provided the attrition methodology. In 1985, a review committee appointed by the Army Models Committee selected the VIC Model to be the Army's Corps-Division level systemic model and it was formally adopted into the Army Model Improvement Program (7:1). In 1990, the Operations Analysis Center of TRAC at Fort Leavenworth assumed proponency for the model.

Model Methodology

VIC takes advantage of its modular nature to replicate a variety of aspects of modern combat. VIC models maneuver forces such as mechanized infantry and armor, engineers, and fire support such as artillery and close air support. Command and control is implicit in the model through the use of input data, unit activities, and tactical decision tables. The model portrays information processing in the form of communications by using precedence delays or fixed delays for message traffic between headquarters. Staff planning and dissemination of information can be represented

in transmission delays which are a function of staff level and available communications equipment. VIC uses sophisticated techniques to achieve "fusion processing" of intelligence data and sensor collection results. A Kalman filtering process is used to predict enemy movements and locations. Electronic warfare is modeled by jammers that can affect communications and radars. VIC models helicopters using attack helicopter teams and cargo and utility helicopters. The helicopters can be used to portray air assaults. Using its Commander lineage, VIC models air sorties replicating an Air Tasking Order (ATO). The sorties model suppression of enemy air defenses (SEAD) and air interdiction (AI). Air attrition is modeled by direct combat between aircraft and by target effects on ground units or other targets in a similar manner to indirect fire. Air Defense Artillery is portrayed as long and short range systems. The air defense artillery module also offers the ability to model air space management. Each type of air defense system is paired with the various types of aircraft to obtain target-firer pairings used in the calculation of attrition. The weakest modules of VIC deal with combat service support. Portrayal of supply functions is limited to Class III and Class V. Maintenance is shown as periodic vehicle or system failures that are factored into attrition

equations. Medical operations are simulated in a manner similar to maintenance.

Battlefield Representation

Terrain in VIC is represented by grid squares. Each grid square has parameters for trafficability and inter-visibility. A typical grid square corresponds to a 1000 meter grid square. However, the user may specify the size of the grid square. The model contains a module that will process digitized terrain files to automate the process of deriving the terrain parameters. Barriers such as minefields and water obstacles such as rivers are represented by line segments that are independent of the grid squares. Each grid square is considered to be homogenous in terms of the parameters. Trafficability is treated as a function of day or night, combat intensity, terrain, weather, and obstacles. Visibility is derived as a function of day or night, weather, the terrain of the observer, the terrain of the entity being observed, and intervening smoke clouds. The visibility of entities is very important in the line of sight (LOS) calculations that are used for sensors to determine targeting.

Weather is modeled by cells in a separate grid from the terrain grid squares. Each cell is a combination of grid squares. Cloud cover and current precipitation type are modeled. Weather within a cell is homogenous.

Ground Maneuver Elements

Each ground unit has an activity. The activities represent various missions that a unit can be assigned. Thetypes of maneuver activity that can occur are:

1) withdrawing while not under attack *
2) withdrawing while under attack
3) delaying while under attack
4) defending a normal defensive position against attack
5) defending against a river crossing
6) defending a terrain feature against attack
7) defending an urban area against attack
8) inactive or regrouping *
9) attacking the enemy at a normal defensive position
10) attacking the enemy protecting a river
11) attacking the enemy at a terrain feature type
12) attacking the enemy in an urban area
13) counter-attacking

14) advancing unopposed *

15) pursuing a withdrawing enemy

* Although no maneuver unit combat is associated with these activities, fire support weapons can cause attrition to weapons in maneuver units during such periods.

Each of the maneuver activities has a corresponding tactical decision table that provides command and control for the unit in conjunction with the designated path points and input form the fusion intelligence module. In addition, each unit type has a template associated with each activity. Units engage each other when they come within their respective engagement ranges when they follow their designated routes or remain stationary in the case of a defender. The decision table logic then dictates the actions of the unit that could result in a change of activities, and formation (in the form of a new template) of the unit. The engagement ranges used are determined from the center to center of the units and are adjusted by the distance of the weapons systems from the center of the unit. Units will continue to fight each other until destroyed or the decision table moves the unit out of engagement range. The decision tables allow phased engagements to replicate command and control measures such as Engagement Areas. Movement of maneuver elements is along routes that are input

for each separate entity. The routes are plotted using path points (nodes). The routes can also be used to plot road networks or movement corridors with the nodes representing road junctions or towns.

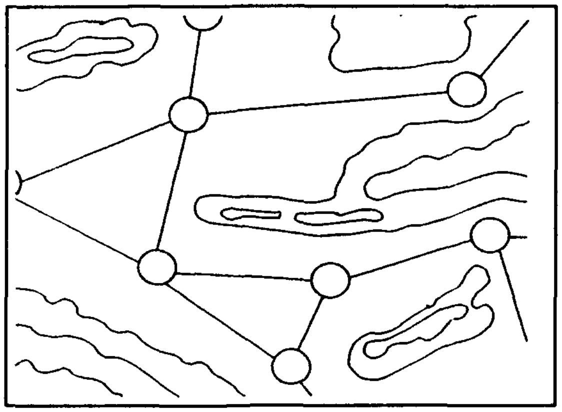


Fig. 2. An Example of Nodes Representing a Road Network

Indirect Fire Attrition

VIC models indirect fire using two different types of attrition based on the target type. For area targets, lethal areas are used. The lethal area method is commonly called the cookie cutter method. A circle representing the lethal radius of the round is overlaid on the units in the target area. The losses are based on the portion of the unit within the lethal area. For point targets, a P(k) against a subclass is used. The target is modeled as a stationary entity which will have a value for various

target-firer pairings such as 155HE vs. a concrete reinforced bunker. The effects of the indirect fires is a function of munition type, firing rate, size of the target, range, sensor and delivery errors, terrain, weather, and the posture of the target.

Direct Fire Attrition

As the templates move along their paths, weapons capable of direct fire may come within the range of targets and vice versa. When this occurs, the maneuver units engage each other, the direct fire attrition module determines the results of the combat. This approach explicitly includes detailed factors of interest to military planners (such as weapon system capabilities, tactical doctrine, and force structure) and has been shown to produce combat predictions essentially identical to those of Monte Carlo simulations (15:586). The basic differential equations of the combat model for all weapon groups i are:

$$\frac{dn_i}{dt} = \sum_{j=1}^{N_{WG}} A_{ji} n_j$$

where: t = time

n_i = the current numerical strength in weapons of the ith weapon group.

n_j = the current numerical strength in weapons of the jth weapon group.

A_{ji} = the current numerical value of the attrition coefficient for a weapon in the jth group engaging weapons in the ith group.

N_{WG} = # of weapon groups being played.

The Lanchester-type equations make several assumptions:

1) Weapons of a given nominal class are equally vulnerable and of equal priority as candidate targets.

2) Line of sight between an observer and a target is an alternating Markov process with two states; visible and invisible (that is, an alternating renewal process in which the time spent in each state is negative-exponentially distributed).

3) The time to acquire a visible target is negative-exponentially distributed; the distribution of the time required to detect a continuously visible target does not depend on the time the searcher has previously been looking.

4) At any given instant, the target acquisition, target selection, and firing processes of a given firer are independent of those processes for other firers.

5) If a target is acquired serially, the time required to attrit that target is negative-exponentially distributed.

VIC simulates a number of processes to model the direct fire between the firer-target pairs. The calculations first determine the relative position of the firer weapon type and the target weapon type as they reside in their respective

subunits (sector of the unit template):

$$DFC = RFU * FDFU$$

$$DTC = RTU * FDTU$$

where:

DFC = firer weapon distance from its unit center

DTC = target weapon distance from its unit center
RFU = firer unit radius

RTU = target unit radius

FDFU = fractional radial distance firer weapon is located from its unit center

FDTU = fractional radial distance target weapon is located from its unit center

It then determines the range between the firer and the target:

$$RNGFT = RNGFTU - DFC - DTC$$

where:

RNGFT = actual firer-target range
RNGFTU = distance from the center of the firer unit to the center of the target unit

The firer must also have line of sight to the target. Line of sight is a function of day or night, weather, the terrain of the observer, the terrain of the entity being observed, and intervening smoke clouds. Once line of sight is established, the firer must acquire a target by one of two target acquisition processes; serial or parallel. Weapons that employ serial acquisition alternately search for and fire at targets, such as a soldier with a rifle. Weapons

employing parallel acquisition can search for new targets while engaging one previously acquired, such as a tank with a commander and a gunner. If more than one target type is seen, the firer selects the highest priority target for engagement. Each weapon type has a priority list for engagement in the model's databases, which gives the user the ability to test different means of doctrinal employment of weapons systems. After a target is selected, the kill rate is determined as a function of the combinations of the probabilities that the firer will hit the target based on four different aspect combinations of moving and stationary, probability of a kill given a hit, projectile flight time, and rate of fire. Losses are calculated by multiplying the attrition coefficient (derived from the kill rate) by the number of firing weapons systems by the time that the weapons systems are firing.

Impact of the Methodology

The direct fire attrition methodology has several problems. The first stems from terrain homogeneity. The line of sight calculations are based on a grid square's average elevation that leads to problems when dealing with rugged terrain that can allow units to engage through

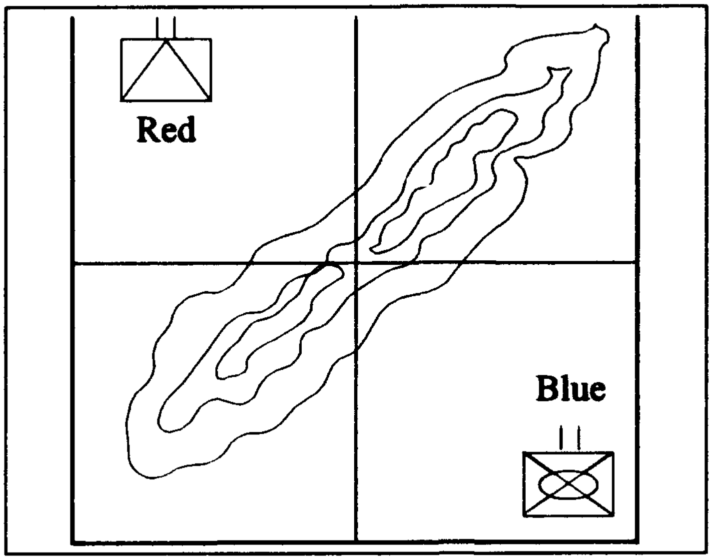


Fig. 3. An Example of How Units can fire through Terrain Features

hillsides. This can occur because the average elevation may not account for intervening terrain such as a ridge between the firer and the target. The second problem dealing with attrition is the absence of fratricide. If the firer and target are on the same side, the corresponding attrition coefficient equals zero. Therefore, a weapons system can not engage friendly forces. Several of the basic assumptions are not completely correct. The assumption that the time to acquire a visible target is negative-exponentially distributed is erroneous. This is because, in general, the system has "memory" and it does "remember" the time of the last event (1:30). The assumption that at any given instant, the target

acquisition, target selection, and firing processes of a given firer are independent of those processes for other firers does not allow for any kind of fire control that is typically used by direct fire weapons systems such as sectors of fire. These assumptions, although erroneous, are essential to the mathematical tractability of the model. We must remember that by definition, a model is " an abstraction of reality."

III. Methodology

Introduction

The purpose of this chapter is to describe the methodology to compare the effects of using the brigade-level templates versus the battalion-level templates. The first section describes the units portrayed as the blue forces and red forces. The second section covers the changes I made to the databases in order to concentrate on the direct fire attrition. The third section reviews the development of the three scenarios--attack, defense, and movement to contact, that were used to compare the two levels of templates. The next section considers the development of the templates. The final section reviews the testing of the templates using CAMEX.

Unit Portrayal

The Blue force represents a brigade from a U.S. mechanized or armored division. The simulated brigade consists of a brigade headquarters and headquarters company, two mechanized infantry battalions, and two armor battalions. Each of the mechanized infantry battalions

contains four rifle companies, one antitank (AT) company, and a headquarters and headquarters company. The primary weapons system of the mechanized battalion is the Bradley fighting vehicle. The antitank company is equipped with the Improved TOW Vehicle. Each of the armor battalions contains four armor companies and a headquarters and headquarters company. The primary weapons system of the armor companies is the M-1 Abrams main battle tank. Both of the headquarters and headquarters companies contain a scout platoon equipped with Cavalry Fighting Vehicles and a heavy mortar platoon equipped with 120mm mortars.

The Red force represents a motorized rifle regiment from a Soviet-style motorized rifle or tank division. The simulated regiment consists of the regimental headquarters, three motorized rifle battalions, one tank battalion, and a reconnaissance company. The regiment also contains an antitank battery and an antiaircraft missile and artillery battery which were combined into the regimental headquarters. The primary weapon of the antitank battery is the AT-3/SAGGER or AT-5/SPANDREL which is mounted on a BRDM-2 armored vehicle. The primary weapons of the antiaircraft missile battery are the SA-9/GASKIN or SA-13 Transporter Erector Launcher (TEL) and the ZSU-23-4 self-propelled antiaircraft gun. Each of the motorized

rifle battalions contains a battalion headquarters, three rifle companies, an antiaircraft platoon, a mortar battery, and an automatic grenade launcher platoon. The primary weapons system of the motorized rifle battalion is the BMP (an infantry fighting vehicle. The primary weapons system of the antiaircraft platoon is the SA-7 or SA-14 shoulder-fired surface-to-air missile. The primary weapon of the automatic grenade launcher platoon is the AGS-17 automatic grenade launcher. The tank battalion contains a battalion headquarters, three tank companies, and a headquarters and service platoon. The primary weapons system of the tank battalion is the T-64/72/80 main battle tank. Several units which are organic to the regiment were not simulated because of the emphasis on the direct fire attrition portion of the model. The self-propelled howitzer battalion and the engineer company were not included because I eliminated the effects of indirect fire and barriers in order to emphasize the direct fire attrition. Other supporting units such as the signal company, the chemical defense company, the motor transport company, the maintenance company, the medical company, and the supply and service platoon receive representation in the form of trucks and trains as part of the regimental headquarters.

Changes to the Simulation

My work with CAMEX used an unclassified set of databases. Certain databases which provide information to the various modules of CAMEX were changed to concentrate on the direct fire attrition element of the simulation. The databases portray a conflict in the terrain of Southwest Asia. All barriers from the terrain and barrier database were removed in order to eliminate possible "kills" from minefields and breaching operations. However, the terrain data was unchanged. No artillery units were used to model indirect fire. However, mortars were modeled as weapons systems since they are normally employed forward in the battle area and may be subject to direct fire. In addition, no aircraft, neither fixed-wing nor rotary-wing were included in the simulation. These steps allowed CAMEX to run and determine attrition of the forces as a result of direct fire only. The front line database was modified to represent the actual numbers of weapons systems present in a full strength U.S. or Soviet-type unit.

Scenario Development

I developed three scenarios with which to compare the results obtained brigade-sized templates with the results

from the battalion-sized templates. First, I developed a movement to contact scenario with the blue force in a typical movement to contact formation and the red force in a typical march formation. Next, I developed an attack scenario with the blue force attacking on two avenues of approach into the red force which was arrayed in a typical defense in depth. Finally, I developed a defense scenario with the blue force arrayed in a linear defense and the red force attacking using two avenues of approach. Each of the scenarios was simulated using each type of template to provide data for comparison. The tactics simulated were simple frontal attacks to eliminate any possible advantage that might be gained by a force represented by battalion-sized templates through the replication of more complicated tactics such as a double envelopment.

The first scenario was the movement to contact. Movement to contact is conducted to gain or reestablish contact with the enemy. It is used to develop the situation early to provide an advantage before decisive engagement (4:3-18). Key aspects of the movement to contact are security and rapid transition to a hasty attack. The blue forces were arrayed with one mechanized battalion as the forward security element, both armor battalions and the brigade headquarters as the main body, and the other

mechanized battalion as the trail element of the main body and rear security. The Soviet-style equivalent to the movement to contact is the march. A march is an organized troop movement conducted in column formation on roads or cross country. It is planned and conducted with the expectation of contact (5:5-1). The red forces were arrayed with the reconnaissance company and one motorized rifle battalion as the advanced guard, followed by the regimental headquarters, the tank battalion, and the two remaining motorized rifle battalions. In order to ensure contact, the two forces were sent directly toward each other with march objectives on the opposite side of their anticipated location of contact.

The second scenario was the deliberate attack. A deliberate attack is conducted when offensive operations are directed and a hasty attack has failed or the enemy is well organized and cannot be turned or bypassed and lead time is available for intelligence gathering and offensive preparation (4:3-22). The blue forces attacked in two columns with each column led by a mechanized infantry battalion and followed by an armor battalion. The red forces used a Soviet-style defense. Soviet defensive planning considers two main foctors--dispersion and depth. Dispersion is to prevent the destruction of multiple units

by nuclear weapons. Depth is used to provide effective fire and maneuver. The main defensive area is normally organized in two echelons and a reserve. The reconnaissance company was positioned forward to provide security. Two motorized rifle battalions comprised the first echelon. The other motorized rifle battalion and the tank battalion comprised the second echelon.

The last scenario was the defense. The main purpose of a defensive operation is to cause an attack to fail by destroying enemy forces (4:4-1). The blue forces were arrayed in three sectors with the two mechanized battalions on the flanks and one of the armor battalions in the center. The other armor battalion served as the brigade reserve. The red forces attacked the blue defenses using a Soviet-style frontal attack. The regiments reconnaissance company led the attack. The attack used two motorized rifle battalions forward in the first echelon, and the remaining motorized rifle battalion and the tank battalion in the second echelon.

Each of the three scenarios was replicated using the brigade-sized templates. Obviously, there was no need to position subordinate elements within the blue or red forces. The single templates were positioned with their centers of mass corresponding to the center of mass of the brigade as

portrayed by the battalion-sized templates. Positioning of subordinates was achieved using the template itself.

Template Development

The data used to create the templates which portray the units on the ground is found in several of the databases. These databases include global ground, ground movement, front line, and template. The global ground database provides the initial location and intended route of each unit in the simulation. This information is used to simulate the commander's maneuver plan. Another crucial element of the template representation is found in the basic deployment radius. This number expressed in meters gives the radius of the unit template. The ground movement database contains the command and control structure of the units which are fighting within the model. The front line database contains the weapon group data for each unit type. The lists provide the number and type of weapons which make up the unit. Tables of Organization and Equipment (TOE) provide the data for the various units. The template database provides a template for each unit prototype. First, it gives the angles of the various pie shapes by an entry for the front angle and the flank angle. The model

considers the two flanks symmetrical and the rear angle is the remainder of the circle's 360 degrees. Then the model lists, for each weapon type, the fraction of the weapon type and its location (in terms of the fraction of the radius from the center of the template) within each of the pie shapes. The model combines this information to represent each unit in the simulation.

The battalion-sized templates were taken directly from the existing unclassified data. However, the numbers of weapons present in each unit were adjusted to represent a full strength unit. The brigade and regiment templates were created by adding up the numbers of each weapons system of the subordinate unit and creating a new weapons group. The new weapons group had a matching unit prototype that was added in the global ground database. A full template was then created to position the various weapons systems.

Testing

Each of the three scenarios was run using the battalion-sized templates to establish a baseline. Then, each of the three scenarios was run using the brigade-sized templates. Each scenario was run for five hours of model simulated time. Five hours was chosen to allow the units

enough time to move to the other's location and engage each other. The length of time was also within the nine hour limit to eliminate divergence problems due to round off error (14:15). At the end of the five hour period, reports of data collected by the model were produced. CAMEX yielded a unit status report which expressed the final value of each unit as a percentage of its original strength , and a cumulative record of killer-victim data for each run. A detailed listing of all of the "kills" was also obtained for each run.

IV. Results

Introduction

I will compare the battalion template representation versus the brigade template representation using several measures of effectiveness. In a study of the stability of the VIC model, researchers recommended defining the statuses of units to reflect the residual ability of units to carry out their assigned missions (14:18). The first measure will compare the percentage of the unit remaining at the end of five hours of simulation in terms of combat power. Combat power is measured from the start using a value based on T-62 equivalents. This percentage of combat power remaining can reveal the ability of the unit to continue with further missions. The measure also gives an idea as to which side "won". The database used by CAMEX considers a unit below twenty percent as combat ineffective. I will also look at the cumulative killer-victim data of each engagement. I will focus on the destruction of the primary weapons systems of the two forces--the tank and the infantry fighting vehicle. The unclassified database represents the blue force's main battle tank as a BMBT and the red force's main battle tank as a RED_TANK. The unclassified database represents the blue force's infantry fighting vehicle as an

IVV and the red force's infantry fighting vehicle as a R_AFV. I will also count the losses of the blue force CVV as a loss of an infantry fighting vehicle because the CVV which represents a Cavalry Fighting Vehicle is a variant of the Bradley fighting vehicle and is virtually identical to the Infantry Fighting Vehicle.

Movement to Contact Scenario

Both movements to contact resulted in blue force victories. However, the run which used the brigade template showed fewer blue force losses and greater red force losses. The table below illustrates the remaining forces for each run:

Movement to Contact Scenario		
Side	Percentage of Original Strength	
	Battalion Templates	Brigade Template
Blue	71.12	90.71
Red	21.22	16.17

Table 1

In terms of the killer-victim scores, both runs resulted in heavy losses of red force tanks and infantry fighting

vehicles. The primary killers the tanks and IFVs changed from the battalion template run to the brigade template run. The battalion template run reported that only the BMBT (blue main battle tank) hit the red tanks. The brigade template

Red Tank Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
BMBT	40	100	12.5	31.25
IVV/BIG			18.31	45.78
CVV/BIG			9.18	22.95
Total	**40**	**100**	**39.99**	**99.98**

Table 2

run showed three systems which killed the red armor. The systems include the blue tank, the infantry fighting vehicle TOW fire (IVV/BIG), and the cavalry fighting vehicle TOW fire (CVV/BIG). A number of blue systems, including the BMBT, the IVV/BIG, the infantry fighting vehicle cannon fire (IVV/CF), the improved TOW vehicle equivalent (ELK), the CVV/BIG, and the cavalry fighting vehicle cannon fire (CVV/CF), caused losses of the red infantry fighting vehicles (R_AFV). In the battalion template run, the IVV killed the majority of the R_AFVs, with the TOW fire

accounting for over 33 percent of the red losses and cannon fire accounting for over 37 percent. In the brigade template run, cannon fire from the IVVs and the CVVs killed the most R_AFVs, with IVV/CF and CVV/CF accounting for over 46 percent and 20 percent of the R_AFV losses respectively.

Red IFV Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
BMBT	2.54	2.35	13.72	12.7
IVV/BIG	36.27	33.58	20.04	18.56
IVV/CF	40.41	37.42	50.43	46.69
ELK	16.89	15.64		
CVV/BIG	5.16	4.78	1.97	1.82
CVV/CF	5.46	5.06	21.83	20.21
Total	**106.73**	**98.82**	**107.99**	**99.99**

Table 3

In contrast to the red tank losses, the blue tank losses are minimal. Only one red weapons system, the R_HEL2 (an armored reconnaissance vehicle) caused blue tank losses.

Blue Tank Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
R_HEL2	7.87	6.78	0.34	0.29
Total	**7.87**	**6.78**	**0.34**	**0.29**

Table 4

Tank losses were virtually nil in the brigade template run and were light in the battalion template run. A number of red systems, including the tank (REDTANK), the infantry fighting vehicle missile (R_AFV/MSL), the infantry fighting vehicle cannon (R_AFV/GUN), the reconnaissance vehicle (R_HEL2), the R_HEL2/50 (a weapon variant), and the RPG16 (an antitank grenade launcher), caused losses of the blue infantry fighting vehicles (IVV/CVV). The percentage of the IVVs and CVVs killed in the battalion template run was nearly twice that of those killed in the brigade template run. In the battalion template run, red tanks did not kill any IVVs or CVVs. The main killers were the R_AFV and the R_HEL2. In the brigade template run, the RPG16 did not play a role in causing losses. The primary killers were the red tank and the R_AFV.

Blue IFV Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
REDTANK/GUN			5.84	4.42
R_AFV/MSL	3.92	2.97	9.68	7.33
R_AFV/GUN	5.79	4.39	5.61	4.25
R_HEL2	13.21	10.01	3.29	2.49
R_HEL2/50	24.53	18.58	1.97	1.49
RPG16	0.03	0.02		
Total	**47.48**	**35.97**	**26.39**	**19.99**

Table 5

Attack Scenario

Both attacks resulted in blue force victories. Similar to the movement to contact scenario, the run which used the brigade template showed fewer blue force losses and greater red force losses. The table below illustrates the remaining forces for each run:

Blue Force Attack Scenario		
Side	Percentage of Original Strength	
	Battalion Templates	Brigade Template
Blue	74.77	90.54
Red	16.59	16.13

Table 6

Both runs resulted in heavy losses of red force tanks and infantry fighting vehicles. The battalion template run reported that the BMBT and the CVV/BIG hit the red tanks. The brigade template run showed the blue tank, the infantry fighting vehicle TOW fire (IVV/BIG), and the cavalry fighting vehicle TOW fire (CVV/BIG) killing the red armor.

Red Tank Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
BMBT	39.42	98.55	4.56	11.4
IVV/BIG			19.76	49.4
CVV/BIG	0.37	0.92	15.68	39.2
Total	**39.79**	**99.47**	**40**	**100**

Table 7

The BMBT, the IVV/BIG, the IVV/CF, the CVV/BIG, and the CVV/CF caused losses of the red infantry fighting vehicles (R_AFV). In the battalion template run, the BMBT killed the majority of the R_AFVs accounting for over 92 percent of the red losses. In the battalion template run, cannon fire from the IVVs and the CVVs killed the most R_AFVs, with IVV/CF and CVV/CF accounting for over 37 percent and 34 percent of the R_AFV losses respectively.

Red IFV Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
BMBT	99.91	92.51	6.39	5.92
IVV/BIG			19.27	17.84
IVV/CF			40.67	37.66
CVV/BIG	3.67	3.4	4.25	3.94
CVV/CF	4.42	4.09	37.42	34.65
Total	**108**	**100**	**108**	**100**

Table 8

In contrast to the red tank losses, the blue tank losses are minimal. In the battalion template run, a number of red systems, including the REDTANK/GUN, the

REDTANK/MSL, R_AFV/MSL, the antitank vehicle missile (BRDM2/MSL), R_HEL2, and the RPG16, caused blue tank losses. Tank losses were virtually nonexistent in the brigade template run and were caused only by the R_HEL2.

Blue Tank Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
REDTANK/GUN	6.49	5.59		
REDTANK/MSL	1.13	0.97		
R_AFV/MSL	4.25	3.66		
BRDM2/MSL	0.58	0.5		
R_HEL2	1.83	1.58	0.51	0.43
RPG16	4.81	4.15		
Total	**19.09**	**16.46**	**0.51**	**0.43**

Table 9

A number of red systems, including the REDTANK/GUN, the R_AFV/MSL, the R_AFV/GUN, the BRDM2/MSL, the antitank vehicle gun (BRDM2/GUN), the R_HEL2, the R_HEL2/50, and the RPG16, caused losses of the blue infantry fighting vehicles (IVV/CVV). In the battalion template run, the main killer was the R_HEL2. In the brigade template run, the RPG16 did

not play a role in causing losses. The killers were the red tank, the R_AFV, and the R_HEL2. Again, the losses were lighter in the brigade template run than the battalion template run by an approximate factor of three to two.

Blue IFV Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
REDTANK/GUN	0.11	0.08	7.15	5.42
R_AFV/MSL	0.02	0.02	7.7	5.83
R_AFV/GUN	1.19	0.9	4.05	3.07
BRDM2/MSL	0.03	0.02		
BRDM2/GUN	0.2	0.15		
R_HEL2	19.55	10.01	5.17	3.92
R_HEL2/50	21.89	18.58	2.64	2
RPG16	0.28	0.02		
Total	**43.27**	**32.78**	**26.71**	**20.23**

Table 10

Defense Scenario

Both defenses resulted in the blue force stopping the attacking red force. The defense scenario followed the

trend set by the other scenarios. The brigade template run which used the showed fewer blue force losses and greater red force losses. Although this scenario followed the general trend, the percentages of remaining forces were closest for this set of runs. The table below illustrates the remaining forces for each run:

Blue Force Defense Scenario		
Side	Percentage of Original Strength	
	Battalion Templates	Brigade Template
Blue	94.38	97.7
Red	19.35	17.73

Table 11

Both runs resulted in heavy losses of red force tanks and infantry fighting vehicles although the number of tanks killed in the battalion template run was considerably less than the number killed in the brigade template run. The battalion template run reported that the IVV/BIG and the CVV/BIG hit the red tanks. The brigade template run showed that only cavalry fighting vehicle TOW fire (CVV/BIG) killed every red tank.

Red Tank Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
IVV/BIG	29.78	74.45		
CVV/BIG	3.66	9.15	40	100
Total	**33.44**	**83.6**	**40**	**100**

Table 12

Both runs revealed the blue defenders eliminated nearly every red infantry fighting vehicle. The battalion template run reported that the IVV and the CVV , using both cannon and TOW fire, caused all of the R_AFV kills. The brigade

Red IFV Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
IVV/BIG	43.62	40.39		
IVV/CF	52.6	48.7		
CVV/BIG	5.28	4.89	8.65	8.01
CVV/CF	6.05	5.6	99.32	91.96
Total	**107.55**	**99.58**	**107.97**	**99.97**

Table 13

template run showed that again only the cavalry fighting vehicle was responsible for the red losses.

The blue tank losses are minuscule. In the battalion template run, the R_HEL and the R_HEL2 combined to kill one tank (0.99) out of one hundred and sixteen. Tank losses were nonexistent in the brigade template run.

Blue Tank Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
R_HEL	0.03	0.02		
R_HEL2	0.96	0.83		
Total	**0.99**	**0.85**		

Table 14

Again, the losses were light in terms of IVVs and CVVs. The R_HEL, the R_HEL/50, the R_HEL2, and the R_HEL2/50 caused losses of the blue infantry fighting vehicles (IVV/CVV) in the battalion template run. Only the R_HEL2 killed blue infantry fighting vehicles in the brigade template run.

Blue IFV Losses				
Killer	Battalion Templates		Brigade Template	
	Number	Percentage	Number	Percentage
R_HEL	0.1	0.08		
R_HEL/50	0.31	0.23		
R_HEL2	1.9	1.44	5.35	4.05
R_HEL2/50	8.32	6.3	1.26	0.95
Total	**10.63**	**8.05**	**6.61**	**5.01**

Table 15

Interpretation of the Results

In each simulation run, the blue forces were the victors. In a first order look at the results in terms of which side won, both the battalion templates and the brigade templates yielded the same results. However, in every case the blue force represented by the brigade templates finished the simulation in better shape, and the red force represented by the battalion templates finished in better shape. This phenomenon can be explained by the consequences of Lanchester's square law. A force gains by concentrating its combat power on the enemy force. Since the enemy losses are dependent on the number of friendly weapons systems

firing on the enemy, a force gains by concentrating its forces. The brigade representation allows the blue forces to achieve a concentration of firepower upon the red forces. This is especially evident in the movement to contact and attack scenarios. The battalion template representation favors forces which defend in depth. In this case, a first echelon attacking unit can be slowed by a front echelon defender. The model methodology allows the second echelon attacker to pass through. While the second echelon attacker passes through, it is subject to fire from the flanks and rear of the first echelon unit as well as fire from the defender's second echelon forces. In this manner, the defender achieves concentration.

Significance of "Stacked Weapons"

Examination of the killer-victim data showed a possible flaw in the direct fire attrition methodology. The flaw showed readily in the brigade template run of the defense scenario. The blue killer-red victim data reveals that one system -- the CVV made almost every kill on the red unit. The CVV is the unclassified database version of the cavalry variant of the Bradley fighting vehicle.

The model representation of the weapons system uses two weapons on one platform. I will term such systems as "stacked weapons." For illustration, I will consider the IVV and CVV since they represent essentially the same vehicle, the Bradley fighting vehicle. The differences between the infantry and cavalry versions are found in crew size and ammunition loads. Each has a weapon representing the TOW (BIG) and the cannon (CF). The cannon is mounted on the IVV/BIG or the CVV/BIG. The IVV/BIG and the CVV/BIG cannot fire when moving. The model represents this by zeroing out the systems fraction of the time it is firing when moving. To avoid the representation of two possible targets to enemy firers, the IVV/CF and the CVV/CF are not subject to direct fire. A kill on the IVV/BIG or the CVV/BIG will result in a kill of both the TOW and cannon systems. The model treats the weapons as independent systems. The direct fire attrition methodology allows the CVV to fire its TOW missile and 25mm cannon simultaneously. Examination of the "camex kills" file reveals that the systems achieve kills at the same time. In reality, the two systems are not independent. The Bradley can only use the TOW <u>or</u> the cannon because the sights are shared. According to experts at the Directorate of Combat Development at the US Army Armor Center at Fort Knox, only one system can

engage at a time because the sight reticle pattern portrays the 25mm cannon sight, the 7.62mm coaxial machine gun sight, or the TOW sight dependent upon the gunner's selection of the weapon. Therefore, the model effectively doubles the firepower of the "stacked weapon" if in fact the combination of weapons systems does not have independent fire controls. The problem is exacerbated by the fact that the two systems can have different target priority lists. For instance, one could be firing on tanks while the other is firing on infantry fighting vehicles. This allows for different killer-victim tables than would occur if only one of the systems was permitted to fire.

A "stacked weapon" which represents a weapons system such as the Bradley fighting vehicle can distort the attrition process because of the basis on Lanchester's square law. Remembering that the basic differential equations of CAMEX for all weapon groups i are:

$$\frac{dn_i}{dt} = \sum_{j=1}^{N_{wg}} A_{ji} n_j$$

where: t = time

n_i = the current numerical strength in weapons of the ith weapon group.

n_j = the current numerical strength in weapons of the jth weapon group.

A_{ji} = the current numerical value of the attrition coefficient for a weapon in the jth group engaging weapons in the ith group.

N_{WG} = # of weapon groups being played.

The attrition over time of each weapon system is a function of the sum of the products of the number of weapons firing at it multiplied by the attrition coefficient.

If we assume a blue force of twenty "stacked" IVVs and a red force of ten "unstacked" tanks and ten "unstacked" BMPs and simulate their combat for three exchanges with assumed attrition coefficients. All systems are within range of all other systems. All attition coefficients are assumed to be fixed at 0.2 for demonstration purposes. For the first exchange, the 20 TOWs from the blue IVVs fire at the red tanks and kill 4 tanks and the 20 cannon fire at the red BMPs and kill 4 of them. At the same time, the 10 red tanks and the 10 red BMPs fire at the 20 blue IVVs killing four of them. In the second exchange, the 16 remaining TOWs fire at the 6 remaining red tanks and kill 3.2 of them. The 16 cannons kill 3.2 of the remaining red BMPs. The 6 red tanks and 6 BMPs fire on the 16 blue IVVs and kill 2.4 of them. In the third exchange, the 13.6 remaining blue TOWs fire at the 2.8 remaining red tanks and kill 2.72 of them. The 13.6 remaining cannons fire at the 2.8 remaining red

BMPs and kill 2.72 of them. The 2.8 red tanks and 2.8 BMPs fire on the 13.6 blue IVVs and kill 1.12 of them. The end result of the three exchanges is that there are 12.48 blue IVVs left and 0.08 red tanks and 0.08 red BMPs left.

If we compare the above situation with one that only allows one IVV weapon system to fire at a time, we see a substantial difference in the end results. In this scenario, half of the IVVs will fire TOWs at the tanks and half will fire their cannons at the BMPs. For the first exchange, 10 TOWs from the blue IVVs fire at the red tanks and kill 2 tanks and 10 cannons fire at the red BMPs and kill 2 of them. At the same time, the 10 red tanks and the 10 red BMPs fire at the 20 blue IVVs killing four of them. In the second exchange, 8 of the remaining IVVs fire TOWs at the 8 remaining red tanks and kill 1.6 of them. The 8 cannons kill 1.6 of the remaining red BMPs. The 8 red tanks and 8 BMPs fire on the 16 blue IVVs and kill 3.2 of them. In the third exchange, the 6.4 remaining blue TOWs fire at the 6.4 remaining red tanks and kill 1.28 of them. The 6.4 remaining cannons fire at the 6.4 remaining red BMPs and kill 1.28 of them. The 6.4 red tanks and 6.4 BMPs fire on the 12.8 blue IVVs and kill 2.56 of them. The end result of the three exchanges is that there are 10.24 blue IVVs left and 5.12 red tanks and 5.12 red BMPs left. If this conflict

were to continue it would result in mutual destruction of both forces. Although these two vignettes are gross simplifications of the attrition process, they illustrate how "stacked weapons" can skew the model results.

To examine the problem of "stacked weapons" within CAMEX, I considered two scenarios in which I caused the IVV and the CVV to only use one of their weapons. The first used the brigade template in the attack. I decided to use cannon fire only in the attack which is doctrinally supported although it eliminates the possibility of overwatching TOW fires. I made the decision to provide a basis for comparison. I disabled the "BIG" fires by zeroing out the system's fraction of the time it is firing when it was stationary. The results of this run were compared to the results obtained from the previous run which used the existing model methodology. The importance of the BMBT increased greatly when the IVV and CVV are represented by a means that is closer to reality. In the cannon fire only run, the BMBT killed all 40 of the red tanks compared to 4.56 red tanks in the run which used the normal modeling methodology. The BMBT also increased the number of red IFV kills to 14.12 which was over double of the 6.39 killed using the standard methodology which allows the use of simultaneous CVV/IVV cannon and TOW fire. The overall

status of the blue forces remained nearly the same, while the ending strength of the red forces increased because of the elimination of the TOW fires.

Blue Force Attack Scenario		
Side	Percentage of Original Strength	
	Cannon Fire Only	"Stacked IVV/CVV"
Blue	90.55	90.54
Red	18.7	16.13

Table 16

The second scenario used the brigade template in the defense. I decided to use TOW fire only in the defense for comparison since the TOW is primarily used in a defensive mode and must be fired from a stationary position. The red tank losses show that in the TOW fire only run that the IVV/BIG kills some (2.46) of the red tanks. This is significant because it represents an increased penetration of the blue defenses. The more significant effect occurs with the red IFV losses. Instead of killing all of the enemy R_AFVs with a combination of cannon and TOW fires, the CVV gets help in killing the R_AFVs from the IVV.
The data for red kills of blue IVV/CVVs reveals an increase

of blue casualties when the blue force uses TOW fire only. This increase in blue casualties results from the decrease in red loss rates caused by the lack of blue firepower gained from simultaneous firings, and the consequent increase in red systems which can cause blue casualties. The increase in blue casualties and the decrease in red casualties are mirrored in the comparison of the final percentage strengths of the two runs.

Blue Force Defense Scenario		
Side	Percentage of Original Strength	
	TOW Fire Only	"Stacked IVV/CVV"
Blue	96.44	97.7
Red	19.71	17.73

Table 17

V. Conclusion

Introduction

This chapter concludes the thesis. The first section summarizes the purpose and the results of the thesis efforts. Several recommendations for further study conclude the chapter.

Summary

This thesis effort was aimed at modeling brigade-sized templates within the CAMEX model, and determining the effects of those templates on the direct fire attrition methodology. The blue force in the model represented a U.S. brigade consisting of two mechanized infantry battalions and two armor battalions. The red force represented a Soviet-style motorized rifle regiment with three motorized rifle battalions, one tank battalion and a reconnaissance company. Three different scenarios were used to simulate combat between the forces. The scenarios included a movement to contact, an attack, and a deliberate defense. Each scenario was run using the battalion-sized templates and again with the brigade-sized templates.

The results revealed that use of the model with brigade-sized templates will demonstrate similar results to those obtained using battalion-sized templates. Both will give the same victor. However, the level of detail of the second order results varies between the two methods. Use of the brigade-sized template speeds scenario generation and data base creation at the expense of eliminating the ability to replicate battalion tactics. The analyst must take this into account when choosing the template size.

In a situation where quick answers are desired, the use of brigade templates can speed data entry and obtain similar results. For instance, if the analyst wants to determine the value of inserting two divisions in the path of a north Korean army in a Northeast Asia scenario, he could use the larger brigade templates to discover the effects that this deployment might have in the conflict.

If the subject under study is weapons effectiveness, greater detail may be required. Tactics play a vital role in the force interactions, even though the goal may be to compare combat effectiveness with two different weapons systems (3:20). For instance, the analyst may be comparing the effectiveness of a battalion equipped with a Bradley equipped scout platoon versus a HMMWV equipped scout platoon. Tactics would play an important role in this

of analysis because of the innate differences in the two vehicles. Therefore, the analyst should choose the smaller template size to consider the effects of tactics.

The simulations also demonstrated a possible flaw in the representation of certain weapons systems such as the Bradley Fighting Vehicle. In the case of the Bradley, the model allows the simultaneous firing of both the TOW system as well as the 25mm cannon. This increases the firepower of the system in the model over that of the actual system, which cannot fire both the TOW and the cannon at the same time. This representation can skew the results of the simulation and radically change the killer-victim data obtained from the model.

Recommendations

First, the portrayal of "stacked weapons" should be checked by analysts to see if it skews the model output using actual classified data. Initial indications show a greater change when the "stacked weapon" spends more time in a stationary posture such as in a defensive posture since the stationary posture allows the simultaneous firings. If the problems with the "stacked weapons" are observed, the problems could invalidate the results of my analysis. To

correct the phenomenon, a weapons use selection algorithm should be added to the model to represent weapons use by "stacked weapons." Such an algorithm could consider factors like target selection, range, mission, and overwatch capabilities.

All work with CAMEX was done with unclassified data. Analysts should replicate this research using actual classified data. In addition, my research efforts focused on the effects of direct fire on the templates. The full model considers a number of other means of attrition such as attack helicopters, fixed wing aircraft, artillery, and mines. The brigade templates should be included in a full fledged simulation run.

Conclusion

The use of brigade-sized templates shows promise as a way to decrease data entry requirements and speed scenario development. However, the gains are not without costs in terms of lost ability to replicate tactics at the battalion level. The Lanchester methodology in CAMEX may require a revision in the portrayal of certain weapons systems which have a choice of weapons to use against the enemy. Analysts

must base their selection of template size on the requirements of the study.

Appendix A: Blue Forces

UNIT NAME	WPN NAME	STRENGTH	MOUNTED ON	DESCRIPTION
B210MX	BRADAR-BOD	5.00	BRADAR-BOD	TEAM PACK
(BDE HHC)	BRADAR-DC	5.00 -		BRADAR-DC TEAMMATE
	APC/CP	6.00 -		APC/CMD TRACK
	BY5/CRM	5.00	BLUETRP	LT ANTI-TANK WPN
	B2AMMO	5.00 -		2-1/2T TRK, AMMO
	B600POL	5.00 -		600 GAL TANK/TRL
	BLUETRP	15.00 -		RIFLE 5.56 M-16A2, SAW, 7.62 SNIPER
	BREV	1.00 -		RECOVERY VEHICLE FULL TRACKED
	BTRK(LT)	15.00 -		TRUCK UTILITY
	BTR	5.00 -		TRAILER CARGO
	LTMG	4.00	BLUETRP	MG8. MM
	M2/50	4.00	BLUETRP	MG .5 GRND & VEH
	B2500POL	5.00 -		MAINT
	BRT(ARMT)	5.00 -		
	BRT(AUTO)	25.00 -		
	BRT(MED)	5.00		
	BS2	8.00 -		
	BS3	10.00 -		
	BS4	6.00 -		
B211MX	BBKNG	36.00	BLUETRP	
(MECH BN)	APC/CP	8.00 -		
	BY5/CRM	35.00	BLUETRP	
	B1800POL	5.00 -		
	B5AMMO	5.00 -		
	BLUETRP	55.00 -		
	BREV	7.00 -		
	BTRK(HV)	5.00 -		
	BTRL	5.00 -		
	LCDG	5.	BLUETRP	
	IVV/CF	54.	IVV/BIG	
	IVV/BIG	54.00 -		
	CVV/BIG	6.00 -		
	CVV/CF	6.00	CVV/BIG	
	ELK	12.00 -		ITV EQUIVALENT
	LTMG	35.	BLUETRP	
	M2/50	42.	BLUETRP	
	MRT/120	6.00 -		
	BS2	8 -		
	BS3	10 -		
	BS4	6 -		

B212MX - MECH BN (ORGANIZED LIKE THE ONE ABOVE)

B213AR	APC/CP	8.00 -		APC/CMD TRACK
(ARMOR BN)	BY5/CRM	15.00	BLUETRP	LIGHT ANTI-TANK WEAPON
	B10AMMO	5.00 -		HEMTT
	B2500POL	5.00 -		HEMTT 2500 GAL/ M978
	BLUETRP	25.00 -		RIFLE 5.56 M-16A2, SAW, 7.62 SNIPER
	BREV	5.00 -		RECOVERY VEHICLE, FULL TRACKED
	BTRK(HV)	5.00 -		TRUCK CARGO
	BTRL	5.00 -		TRAILER CARGO
	LCDG	5.	BLUETRP	TARGET DESIGNATOR
	CVV/BIG	6. -		SCOUT AFV
	CVV/CF	6.	CVV/BIG	" "
	LTMG	9.	BLUETRP	MG8. MM
	BMBT	58.00 -		BLUE TANK
	M2/50	5.	BLUETRP	MG .5 GRND & VEH
	MRT/120	6.00 -		120MM SP MORTAR
	BS2	8 -		
	BS3	10 -		
	BS4	6 -		

B231AR - ARMOR BN (ORGANIZED LIKE THE ONE ABOVE)

Appendix B: Red Forces

UNIT NAME	WPN NAME	STRENGTH	MOUNTED ON	DESCRIPTION
R240MR (REGT HQS)	2S6/30MM	4.00 -		ANTI-AIRCRAFT SYSTEM, ZSU 23-4 ADA CO
	ACV/RCP	3.00 -		MOBL CMD POST; ACV; ACRV
	RATRK	4.00 -		TRUCK
	REDTRP	74.00 -		SNIPER RIFLE; ASSAULT RIFLE; LMG
	RPG16	9.00 -		ATGL,RPG-16 FO
	BRDM2/GUN	9.00	BRDM2/MSL	ANTITANK CO
	BRDM2/MSL	9.00 -		APC
	RPTRK	4.00 -		TRUCK, POL
	RREC	4.00 -		TRUCK, RECOVERY
	RSTRK	14.00 -		TRUCK
	SA18(FO)	3.00 -		PLANE SHOOTER
	SAX15	4.00 -		ADA CO
	RRADAR5	4.00 -		BRITZ RADAR
	RRADAR3	4.00 -		CNN NEWS CREW
	RRADAR1	4.00 -		ABC NEWS CREW
	REDSTF	32 -		
R241MB (MRB)	120/MTR	6.00 -		BIG MORTAR
	BT217	6.00 -		30MM AUTO GREN LCHR,BT2-17
	R_AFV/GUN	36.	R_AFV/MSL	IFV
	R_AFV/MSL	36.00 -		IFV
	ACV/RCP	3.00 -		MOBL CMD POST
	RATRK	13.00 -		TRUCK
	REDTRP	34.00 -		SNIPER RIFLE; ASSAULT RIFLE; LMG
	RPG16	35.00 -		ATGL,RPG-16 FO
	RPTRK	2.00 -		TRUCK, POL
	RSTRK	4.00 -		TRUCK
	SA18(FO)	9.00 -		PLANE SHOOTER
	REDSTF	18 -		
R242MB	- MOTORIZED RIFLE BATTALION (ORGANIZED LIKE THE ONE ABOVE)			
R243MB	- MOTORIZED RIFLE BATTALION (ORGANIZED LIKE THE ONE ABOVE)			
R240RE (RECON CO)	R_HEL	4.00 -		ARMD RECON VEH, R_HEL
	R_HEL/50	4.	R_HEL	
	REDTRP	4.00 -		SNIPER RIFLE; ASSAULT RIFLE; LMG
	RPG16	4.00 -		
	R_HEL2	4.00 -		ARMD RECON VEH,

				R_HEL2
	R_HEL2/50	4.	R_HEL2	
	REDSTF	4 -		
R244TB (TANK BN)	ACV/RCP	2.00 -		MOBL CMD POST; ACV; ACRV
	RED_TANK/GUN	40.00 -		TANK
	RED_TANK/MSL	40.00	RED_TANK/GUN	TANK
	DZRBLD	12.00	RED_TANK/GUN	DOZER BLADE, MOUNTED ON EVERY THIRD TANK
	REDTRP	4.00 -		SNIPER RIFLE; ASSAULT RIFLE; LMG
	RPG16	2.00 -		ATGL,RPG-16 FO
	RPTRK	3.00 -		TRUCK, POL
	RSTRK	11.00 -		TRUCK
	REDSTF	22.00 -		

Appendix C: Cumulative Kills

This appendix records the cumulative kills for the Movement to Contact scenario using battalion-sized templates. The data represents cumulative kills for all five hours of simulation time.

BLUE KILLS

BMBT	RED_TANK/GUN	40.00
BMBT	RED_TANK/MSL	40.00
BMBT	R_AFV/MSL	2.54
BMBT	R_AFV/GUN	2.54
BMBT	DZRBLD	12.00
BMBT	ACV/RCP	2.27
IVV/BIG	R_AFV/MSL	36.27
IVV/BIG	R_AFV/GUN	36.27
IVV/BIG	R_HEL	1.33
IVV/BIG	R_HEL/50	1.33
IVV/BIG	ACV/RCP	3.75
IVV/CF	R_AFV/MSL	40.41
IVV/CF	R_AFV/GUN	40.41
IVV/CF	BT217	6.51
IVV/CF	RPG16	19.47
IVV/CF	SA18(FO)	.18
ELK	R_AFV/MSL	16.89
ELK	R_AFV/GUN	16.89
ELK	R_HEL	2.42
ELK	R_HEL/50	2.42
ELK	ACV/RCP	.42
CVV/BIG	R_AFV/MSL	5.16
CVV/BIG	R_AFV/GUN	5.16
CVV/BIG	R_HEL	.25
CVV/BIG	R_HEL/50	.25
CVV/BIG	ACV/RCP	1.16
CVV/CF	R_AFV/MSL	5.46
CVV/CF	R_AFV/GUN	5.46
CVV/CF	BT217	.07
CVV/CF	RPG16	2.50
CVV/CF	SA18(FO)	.02
BLUETRP	RPG16	.15
BLUETRP	REDTRP	4.00

RED KILLS

R_AFV/MSL	IVV/BIG	3.83
R_AFV/MSL	IVV/CF	3.83
R_AFV/MSL	ELK	5.30
R_AFV/MSL	CVV/BIG	.09
R_AFV/MSL	CVV/CF	.09
R_AFV/MSL	APC/CP	.00
R_AFV/GUN	IVV/BIG	5.45
R_AFV/GUN	IVV/CF	5.45
R_AFV/GUN	CVV/BIG	.34
R_AFV/GUN	CVV/CF	.34
R_AFV/GUN	BY5/CRM	18.75
R_AFV/GUN	BLUETRP	29.46
R_AFV/GUN	LTMG	18.75
R_AFV/GUN	M2/50	22.50
R_AFV/GUN	BBKNG	19.28
R_AFV/GUN	LCDG	2.68
R_AFV/GUN	APC/CP	.06
R_HEL2	BMBT	7.87
R_HEL2	IVV/BIG	12.72
R_HEL2	IVV/CF	12.72
R_HEL2	ELK	11.77
R_HEL2	CVV/BIG	.49
R_HEL2	CVV/CF	.49
R_HEL2	APC/CP	1.48
R_HEL2/50	IVV/BIG	23.03
R_HEL2/50	IVV/CF	23.03
R_HEL2/50	CVV/BIG	1.50
R_HEL2/50	CVV/CF	1.50
R_HEL2/50	BY5/CRM	14.59
R_HEL2/50	BLUETRP	23.30
R_HEL2/50	LTMG	13.02
R_HEL2/50	M2/50	14.10
R_HEL2/50	BBKNG	10.97
R_HEL2/50	LCDG	2.83
R_HEL2/50	APC/CP	2.93
BT217	BY5/CRM	.09
BT217	BLUETRP	.14
BT217	LTMG	.09
BT217	M2/50	.11
BT217	BBKNG	.09
BT217	LCDG	.01
RPG16	IVV/BIG	.03
RPG16	IVV/CF	.03
RPG16	ELK	.01
RPG16	CVV/BIG	.00
RPG16	CVV/CF	.00
REDTRP	BY5/CRM	.50
REDTRP	BLUETRP	.79
REDTRP	LTMG	.50
REDTRP	M2/50	.61
REDTRP	BBKNG	.52
REDTRP	LCDG	.07

Appendix D: Cumulative Kills

This appendix records the cumulative kills for the Movement to Contact scenario using brigade-sized templates. The data represents cumulative kills for all five hours of simulation time.

<u>BLUE KILLS</u>

BMBT	RED_TANK/GUN	12.50
BMBT	RED_TANK/MSL	12.50
BMBT	R_AFV/MSL	13.72
BMBT	R_AFV/GUN	13.72
BMBT	2S6/30MM	.79
BMBT	DZRBLD	3.75
IVV/BIG	RED_TANK/GUN	18.31
IVV/BIG	RED_TANK/MSL	18.31
IVV/BIG	R_AFV/MSL	20.04
IVV/BIG	R_AFV/GUN	20.04
IVV/BIG	BRDM2/MSL	8.97
IVV/BIG	BRDM2/GUN	8.97
IVV/BIG	2S6/30MM	2.82
IVV/BIG	DZRBLD	5.49
IVV/CF	R_AFV/MSL	50.43
IVV/CF	R_AFV/GUN	50.43
IVV/CF	BT217	14.99
IVV/CF	RPG16	10.79
IVV/CF	2S6/30MM	.35
IVV/CF	SA18(FO)	9.28
CVV/BIG	RED_TANK/GUN	9.18
CVV/BIG	RED_TANK/MSL	9.18
CVV/BIG	R_AFV/MSL	1.97
CVV/BIG	R_AFV/GUN	1.97
CVV/BIG	BRDM2/MSL	.00
CVV/BIG	BRDM2/GUN	.00
CVV/BIG	R_HEL	4.00
CVV/BIG	R_HEL/50	4.00
CVV/BIG	2S6/30MM	.00
CVV/BIG	DZRBLD	2.75
CVV/CF	R_AFV/MSL	21.83
CVV/CF	R_AFV/GUN	21.83
CVV/CF	BRDM2/MSL	.03
CVV/CF	BRDM2/GUN	.03
CVV/CF	BT217	2.60
CVV/CF	RPG16	.12
CVV/CF	2S6/30MM	.04
CVV/CF	SA18(FO)	.20

RED KILLS

RED_TANK/GUN	CVV/BIG	5.84
RED_TANK/GUN	CVV/CF	5.84
R_AFV/MSL	CVV/BIG	9.68
R_AFV/MSL	CVV/CF	9.68
R_AFV/GUN	CVV/BIG	5.61
R_AFV/GUN	CVV/CF	5.61
R_HEL2	BMBT	.34
R_HEL2	IVV/BIG	.95
R_HEL2	IVV/CF	.95
R_HEL2	CVV/BIG	2.34
R_HEL2	CVV/CF	2.34
R_HEL2/50	IVV/BIG	1.45
R_HEL2/50	IVV/CF	1.45
R_HEL2/50	CVV/BIG	.52
R_HEL2/50	CVV/CF	.52

Appendix E: Cumulative Kills

This appendix records the cumulative kills for the Attack scenario using battalion-sized templates. The data represents cumulative kills for all five hours of simulation time.

BLUE KILLS

BMBT	RED_TANK/GUN	39.42
BMBT	RED_TANK/MSL	39.42
BMBT	R_AFV/MSL	99.91
BMBT	R_AFV/GUN	99.91
BMBT	BRDM2/MSL	7.77
BMBT	BRDM2/GUN	7.77
BMBT	2S6/30MM	3.54
BMBT	DZRBLD	11.83
BMBT	ACV/RCP	8.75
IVV/BIG	ACV/RCP	1.08
IVV/CF	BT217	.97
IVV/CF	RPG16	8.57
ELK	R_HEL	4.00
ELK	R_HEL/50	4.00
ELK	ACV/RCP	.94
CVV/BIG	RED_TANK/GUN	.37
CVV/BIG	RED_TANK/MSL	.37
CVV/BIG	R_AFV/MSL	3.67
CVV/BIG	R_AFV/GUN	3.67
CVV/BIG	BRDM2/MSL	.21
CVV/BIG	BRDM2/GUN	.21
CVV/BIG	2S6/30MM	.08
CVV/BIG	DZRBLD	.11
CVV/BIG	ACV/RCP	.90
CVV/CF	R_AFV/MSL	4.42
CVV/CF	R_AFV/GUN	4.42
CVV/CF	BRDM2/MSL	1.02
CVV/CF	BRDM2/GUN	1.02
CVV/CF	BT217	.51
CVV/CF	RPG16	18.67
CVV/CF	2S6/30MM	.37
CVV/CF	SA18(FO)	3.24
BLUETRP	BT217	.29
BLUETRP	RPG16	2.23
BLUETRP	SA18(FO)	.00
BLUETRP	REDTRP	17.11

RED KILLS

RED_TANK/GUN	BMBT	6.49
RED_TANK/GUN	CVV/BIG	.11
RED_TANK/GUN	CVV/CF	.11
RED_TANK/MSL	BMBT	1.13
RED_TANK/MSL	CVV/BIG	.00
RED_TANK/MSL	CVV/CF	.00
R_AFV/MSL	BMBT	4.25
R_AFV/MSL	CVV/BIG	.02
R_AFV/MSL	CVV/CF	.02
R_AFV/MSL	APC/CP	.00
R_AFV/GUN	CVV/BIG	1.19
R_AFV/GUN	CVV/CF	1.19
R_AFV/GUN	BY5/CRM	5.55
R_AFV/GUN	BLUETRP	9.25
R_AFV/GUN	LTMG	3.33
R_AFV/GUN	M2/50	1.85
R_AFV/GUN	LCDG	1.85
R_AFV/GUN	APC/CP	.14
BRDM2/MSL	BMBT	.58
BRDM2/MSL	CVV/BIG	.03
BRDM2/MSL	CVV/CF	.03
BRDM2/MSL	APC/CP	.00
BRDM2/GUN	CVV/BIG	.20
BRDM2/GUN	CVV/CF	.20
BRDM2/GUN	BY5/CRM	1.14
BRDM2/GUN	BLUETRP	1.91
BRDM2/GUN	LTMG	.69
BRDM2/GUN	M2/50	.38
BRDM2/GUN	LCDG	.38
BRDM2/GUN	APC/CP	.08
R_HEL2	BMBT	1.83
R_HEL2	IVV/BIG	18.59
R_HEL2	IVV/CF	18.59
R_HEL2	ELK	8.42
R_HEL2	CVV/BIG	.96
R_HEL2	CVV/CF	.96
R_HEL2	APC/CP	3.64
R_HEL2/50	IVV/BIG	20.21
R_HEL2/50	IVV/CF	20.21
R_HEL2/50	CVV/BIG	1.68
R_HEL2/50	CVV/CF	1.68
R_HEL2/50	BY5/CRM	16.04
R_HEL2/50	BLUETRP	32.10
R_HEL2/50	LTMG	14.91
R_HEL2/50	M2/50	16.97
R_HEL2/50	BBKNG	11.14
R_HEL2/50	LCDG	1.68
R_HEL2/50	APC/CP	7.48
BT217	BY5/CRM	1.58
BT217	BLUETRP	2.64
BT217	LTMG	.95
BT217	M2/50	.53
BT217	LCDG	.53
RPG16	BMBT	4.81
RPG16	CVV/BIG	.28

RPG16	CVV/CF	.28
REDTRP	BY5/CRM	4.13
REDTRP	BLUETRP	7.00
REDTRP	LTMG	2.49
REDTRP	M2/50	1.42
REDTRP	LCDG	1.35

Appendix F: Cumulative Kills

This appendix records the cumulative kills for the Attack scenario using brigade-sized templates. The data represents cumulative kills for all five hours of simulation time.

BLUE KILLS

BMBT	RED_TANK/GUN	4.56
BMBT	RED_TANK/MSL	4.56
BMBT	R_AFV/MSL	6.39
BMBT	R_AFV/GUN	6.39
BMBT	DZRBLD	1.37
IVV/BIG	RED_TANK/GUN	19.76
IVV/BIG	RED_TANK/MSL	19.76
IVV/BIG	R_AFV/MSL	19.27
IVV/BIG	R_AFV/GUN	19.27
IVV/BIG	BRDM2/MSL	8.91
IVV/BIG	BRDM2/GUN	8.91
IVV/BIG	2S6/30MM	3.63
IVV/BIG	DZRBLD	5.93
IVV/CF	R_AFV/MSL	40.67
IVV/CF	R_AFV/GUN	40.67
IVV/CF	BT217	13.05
IVV/CF	RPG16	10.38
IVV/CF	2S6/30MM	.26
IVV/CF	SA18(FO)	12.15
CVV/BIG	RED_TANK/GUN	15.68
CVV/BIG	RED_TANK/MSL	15.68
CVV/BIG	R_AFV/MSL	4.25
CVV/BIG	R_AFV/GUN	4.25
CVV/BIG	BRDM2/MSL	.00
CVV/BIG	BRDM2/GUN	.00
CVV/BIG	R_HEL	4.00
CVV/BIG	R_HEL/50	4.00
CVV/BIG	2S6/30MM	.00
CVV/BIG	DZRBLD	4.70
CVV/CF	R_AFV/MSL	37.42
CVV/CF	R_AFV/GUN	37.42
CVV/CF	BRDM2/MSL	.09
CVV/CF	BRDM2/GUN	.09
CVV/CF	BT217	4.89
CVV/CF	RPG16	.38
CVV/CF	2S6/30MM	.10
CVV/CF	SA18(FO)	.48

RED KILLS

RED_TANK/GUN	CVV/BIG	7.15
RED_TANK/GUN	CVV/CF	7.15
R_AFV/MSL	CVV/BIG	7.70
R_AFV/MSL	CVV/CF	7.70
R_AFV/GUN	CVV/BIG	4.05
R_AFV/GUN	CVV/CF	4.05
R_HEL2	BMBT	.51
R_HEL2	IVV/BIG	.96
R_HEL2	IVV/CF	.96
R_HEL2	CVV/BIG	4.21
R_HEL2	CVV/CF	4.21
R_HEL2/50	IVV/BIG	1.76
R_HEL2/50	IVV/CF	1.76
R_HEL2/50	CVV/BIG	.88
R_HEL2/50	CVV/CF	.88

Appendix G: Cumulative Kills

This appendix records the cumulative kills for the Defense scenario using battalion-sized templates. The data represents cumulative kills for all five hours of simulation time.

<u>BLUE KILLS</u>

BMBT	,	BRDM2/MSL	,	9.00
BMBT	,	BRDM2/GUN	,	9.00
BMBT	,	2S6/30MM	,	4.00
BMBT	,	ACV/RCP	,	3.00
IVV/BIG	,	RED_TANK/GUN	,	29.78
IVV/BIG	,	RED_TANK/MSL	,	29.78
IVV/BIG	,	R_AFV/MSL	,	43.62
IVV/BIG	,	R_AFV/GUN	,	43.62
IVV/BIG	,	R_HEL	,	2.19
IVV/BIG	,	R_HEL/50	,	2.19
IVV/BIG	,	DZRBLD	,	8.94
IVV/BIG	,	ACV/RCP	,	7.60
IVV/CF	,	R_AFV/MSL	,	52.60
IVV/CF	,	R_AFV/GUN	,	52.60
IVV/CF	,	BT217	,	15.82
IVV/CF	,	RPG16	,	13.66
IVV/CF	,	SA18(FO)	,	3.00
ELK	,	R_HEL	,	1.49
ELK	,	R_HEL/50	,	1.49
CVV/BIG	,	RED_TANK/GUN	,	3.66
CVV/BIG	,	RED_TANK/MSL	,	3.66
CVV/BIG	,	R_AFV/MSL	,	5.28
CVV/BIG	,	R_AFV/GUN	,	5.28
CVV/BIG	,	R_HEL	,	.32
CVV/BIG	,	R_HEL/50	,	.32
CVV/BIG	,	DZRBLD	,	1.10
CVV/BIG	,	ACV/RCP	,	1.57
CVV/CF	,	R_AFV/MSL	,	6.05
CVV/CF	,	R_AFV/GUN	,	6.05
CVV/CF	,	BT217	,	1.39
CVV/CF	,	RPG16	,	.60
BLUETRP	,	REDTRP	,	59.55

RED KILLS

R_HEL	BMBT	.03
R_HEL	IVV/BIG	.10
R_HEL	IVV/CF	.10
R_HEL	ELK	.13
R_HEL	CVV/BIG	.00
R_HEL	CVV/CF	.00
R_HEL	APC/CP	.00
R_HEL/50	IVV/BIG	.29
R_HEL/50	IVV/CF	.29
R_HEL/50	CVV/BIG	.02
R_HEL/50	CVV/CF	.02
R_HEL/50	BY5/CRM	.15
R_HEL/50	BLUETRP	.23
R_HEL/50	LTMG	.15
R_HEL/50	M2/50	.17
R_HEL/50	BBKNG	.15
R_HEL/50	LCDG	.02
R_HEL/50	APC/CP	.03
R_HEL2	BMBT	.96
R_HEL2	IVV/BIG	1.47
R_HEL2	IVV/CF	1.47
R_HEL2	ELK	4.22
R_HEL2	CVV/BIG	.43
R_HEL2	CVV/CF	.43
R_HEL2	APC/CP	.28
R_HEL2/50	IVV/BIG	7.83
R_HEL2/50	IVV/CF	7.83
R_HEL2/50	CVV/BIG	.49
R_HEL2/50	CVV/CF	.49
R_HEL2/50	BY5/CRM	2.60
R_HEL2/50	BLUETRP	4.14
R_HEL2/50	LTMG	2.40
R_HEL2/50	M2/50	2.69
R_HEL2/50	BBKNG	2.16
R_HEL2/50	LCDG	.47
R_HEL2/50	APC/CP	1.00

Appendix H: Cumulative Kills

This appendix records the cumulative kills for the Defense scenario using brigade-sized templates. The data represents cumulative kills for all five hours of simulation time.

BLUE KILLS

IVV/CF	BT217	.08
CVV/BIG	RED_TANK/GUN	40.00
CVV/BIG	RED_TANK/MSL	40.00
CVV/BIG	R_AFV/MSL	8.65
CVV/BIG	R_AFV/GUN	8.65
CVV/BIG	BRDM2/MSL	3.39
CVV/BIG	BRDM2/GUN	3.39
CVV/BIG	R_HEL	4.00
CVV/BIG	R_HEL/50	4.00
CVV/BIG	2S6/30MM	2.00
CVV/BIG	DZRBLD	12.00
CVV/CF	R_AFV/MSL	99.32
CVV/CF	R_AFV/GUN	99.32
CVV/CF	BRDM2/MSL	1.85
CVV/CF	BRDM2/GUN	1.85
CVV/CF	BT217	17.92
CVV/CF	RPG16	8.79
CVV/CF	2S6/30MM	2.00
CVV/CF	SA18(FO)	21.96

RED KILLS

R_AFV/MSL	CVV/BIG	.00
R_AFV/MSL	CVV/CF	.00
R_AFV/GUN	CVV/BIG	.00
R_AFV/GUN	CVV/CF	.00
R_HEL2	IVV/BIG	.30
R_HEL2	IVV/CF	.30
R_HEL2	CVV/BIG	5.05
R_HEL2	CVV/CF	5.05
R_HEL2/50	IVV/BIG	.19
R_HEL2/50	IVV/CF	.19
R_HEL2/50	CVV/BIG	1.07
R_HEL2/50	CVV/CF	1.07

Appendix I: Cumulative Kills

This appendix records the cumulative kills for an Attack scenario using brigade-sized templates in which the BIG (TOW) fire was disabled for the IVV and CVV. The BIG (TOW) fire was disabled to show the significance of the representation of "stacked weapons."

BLUE KILLS

BMBT	RED_TANK/GUN	40.00
BMBT	RED_TANK/MSL	40.00
BMBT	R_AFV/MSL	14.12
BMBT	R_AFV/GUN	14.12
BMBT	R_HEL	4.00
BMBT	R_HEL/50	4.00
BMBT	2S6/30MM	3.11
BMBT	DZRBLD	12.00
IVV/CF	R_AFV/MSL	49.83
IVV/CF	R_AFV/GUN	49.83
IVV/CF	BRDM2/MSL	2.45
IVV/CF	BRDM2/GUN	2.45
IVV/CF	BT217	12.47
IVV/CF	RPG16	10.23
IVV/CF	2S6/30MM	.75
IVV/CF	SA18(FO)	8.67
CVV/CF	R_AFV/MSL	44.05
CVV/CF	R_AFV/GUN	44.05
CVV/CF	BRDM2/MSL	.03
CVV/CF	BRDM2/GUN	.03
CVV/CF	BT217	5.47
CVV/CF	RPG16	.12
CVV/CF	2S6/30MM	.14
CVV/CF	SA18(FO)	.76

RED KILLS

RED_TANK/GUN	CVV/BIG	.26
RED_TANK/GUN	CVV/CF	.26
R_AFV/MSL	CVV/BIG	6.93
R_AFV/MSL	CVV/CF	6.93
R_AFV/GUN	CVV/BIG	1.92
R_AFV/GUN	CVV/CF	1.92
R_HEL	CVV/BIG	5.97
R_HEL	CVV/CF	5.97
R_HEL/50	CVV/BIG	1.42
R_HEL/50	CVV/CF	1.42
R_HEL2	BMBT	.51
R_HEL2	IVV/BIG	.96
R_HEL2	IVV/CF	.96
R_HEL2	CVV/BIG	6.44
R_HEL2	CVV/CF	6.44

R_HEL2/50	IVV/BIG	1.73
R_HEL2/50	IVV/CF	1.73
R_HEL2/50	CVV/BIG	1.06
R_HEL2/50	CVV/CF	1.06

Appendix I: Cumulative Kills

This appendix records the cumulative kills for a Defense scenario using brigade-sized templates in which the CF (cannon fire) was disabled for the IVV and CVV. The CF (cannon fire) was disabled to show the significance of the representation of "stacked weapons."

BLUE KILLS

IVV/BIG	RED_TANK/GUN	2.46
IVV/BIG	RED_TANK/MSL	2.46
IVV/BIG	R_AFV/MSL	47.92
IVV/BIG	R_AFV/GUN	47.92
IVV/BIG	DZRBLD	.74
CVV/BIG	RED_TANK/GUN	37.54
CVV/BIG	RED_TANK/MSL	37.54
CVV/BIG	R_AFV/MSL	60.08
CVV/BIG	R_AFV/GUN	60.08
CVV/BIG	BRDM2/MSL	7.60
CVV/BIG	BRDM2/GUN	7.60
CVV/BIG	R_HEL	4.00
CVV/BIG	R_HEL/50	4.00
CVV/BIG	2S6/30MM	4.00
CVV/BIG	DZRBLD	11.26

RED KILLS

R_AFV/MSL	CVV/BIG	.03
R_AFV/GUN	CVV/BIG	.01
R_HEL2	BMBT	.21
R_HEL2	IVV/BIG	.30
R_HEL2	CVV/BIG	7.42
R_HEL2/50	IVV/BIG	.63
R_HEL2/50	CVV/BIG	1.63

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Vita

Captain Douglas A. Hersh was born on 15 June 1963 in Waynesboro, Pennsylvania. He graduated from the Waynesboro Area Senior High School in 1981 and entered the United States Military Academy in July 1981. In 1985, he graduated from West Point with a Bachelor of Science degree in Engineering Management, and was commissioned as an Infantry officer.

In 1986, CPT Hersh was assigned to the 2nd Infantry Division at Camp Howze, Republic of Korea. While there, he served as a rifle platoon leader, a rifle company executive officer, and a headquarters and headquarters company executive officer. In 1989, he was assigned to the 2nd Battalion, 75th Ranger Regiment at Fort Lewis, Washington, where he served as a ranger platoon leader and executive officer.

In 1990, CPT Hersh was assigned to the 193d Infantry Brigade in the Republic of Panama. While serving in Panama, CPT Hersh held the positions of brigade air operations officer, company commander, and brigade assistant operations officer.

In August 1992, after his assignment in Panama, CPT Hersh entered the School of Engineering, Air Force Institute of Technology.

Permanent Address: 13200 Old Mill Road
Waynesboro, PA 17268

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13. ABSTRACT *(Maximum 200 words)*

This thesis effort modeled brigade-sized templates within the CAMEX model, and determined the effects of those templates on the direct fire attrition methodology. The model simulated combat between a U.S. brigade from a mechanized or armored division and a Soviet-style motorized rifle regiment. Three different scenarios were used to simulate combat between the forces. The scenarios included a movement to contact, an attack, and a deliberate defense. Each scenario was run using the battalion-sized templates and again with the brigade-sized templates. The results revealed that use of the model with brigade-sized templates will demonstrate similar results to those obtained using battalion-sized templates. The simulations also demonstrated a possible flaw in the representation of certain weapons systems such as the Bradley Fighting Vehicle. The use of brigade-sized templates shows promise as a way to decrease data entry requirements and speed scenario development. However, the gains are not without costs in terms of lost ability to replicate tactics at the battalion level.

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